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Discovery of a new Wolf-Rayet star using SAGE-LMC

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Abstract. We report the first-ever discovery of an extragalactic Wolf-Rayet (WR) star with *Spitzer*. A new WR star in the Large Magellanic Cloud (LMC) was revealed via detection of its circumstellar shell using 24 μm images obtained in the framework of the *Spitzer* Survey of the Large Magellanic Cloud (SAGE-LMC). Subsequent spectroscopic observations with the Gemini South resolved the central star in two components, one of which is a WN3b+abs star, while the second one is a B0 V star. We consider the lopsided brightness distribution over the circumstellar shell as an indication that the WR star is a runaway and use this interpretation to identify a possible parent cluster of the star.

1. Introduction

Massive stars are sources of copious stellar wind, which creates circumstellar shells of a wide range of morphologies (Nota et al. 1995; Weis 2001). Detection of such nebulae by means of infrared observations accompanied by spectroscopic follow-ups of their central stars provide a useful tool for revealing evolved massive stars (Gvaramadze et al. 2009, 2010a,b; Gvaramadze, Kniazev & Fabrika 2010; Wachter et al. 2010, 2011). In this paper, we report the discovery of a new WR star in the LMC using this tool.

2. A new WR star and its circular shell in the LMC

The new circular shell (Figure 1) was discovered using the 24 μm SAGE-LMC data (Meixner 2006) during our search for bow shocks around runaway OB stars in the LMC (for motivation and the results of this search see Gvaramadze, Kroupa & Pflamm-Altenburg 2010). To determine the spectral type of the central star associated with the shell we obtained its spectrum with the Gemini Multi-Object Spectrograph South (GMOS-S). The acquisition image resolved the central star in two components, hereafter star 1 and star 2 (see middle panel of Figure 1).

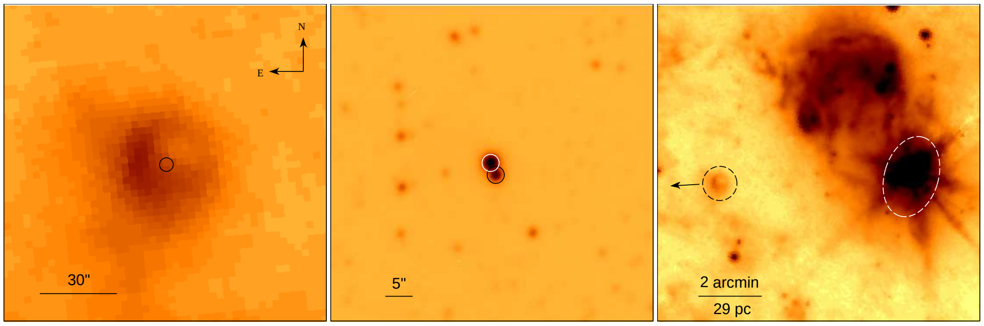

Figure 1. *Left*: *Spitzer* 24 μm image of the new circular shell in the LMC. The position of the central star is marked by a circle. *Middle*: Acquisition image of the central star showing that it is composed of two components, star 1 (new WR star; indicated by a white circle) and star 2 (black circle). *Right*: 24 μm image of the open cluster NGC 1722 (indicated by a dashed ellipse) with the position of the shell marked by a circle. The arrow shows the direction of motion of the WR star, as suggested by the brightness asymmetry of its shell. The orientation of the images is the same.

Figure 2 shows the normalized spectrum of star 1 obtained with the GMOS-S in a long-slit mode. The spectrum is dominated by strong emissions of He II λ 4686, N V $\lambda\lambda$ 4603, 4620, 4944 and Hα. The Hα and the He II λ 4686 lines show central absorption reversals. The spectrum also shows several lower-intensity broad emission features with narrow absorption reversals, of which the most prominent are Hβ and He II λ5412. Other H and He lines are almost purely in absorption. The presence of the N V $\lambda\lambda$ 4603, 4620 emission lines and the absence of the N III $\lambda\lambda$ 4634-41 multiplet implies that the emission spectrum belongs to the ionization subclass WN3 (Smith, Shara & Moffat 1996). The FWHM of the He II λ 4686 (emission) line of 31.1 Å is quite large and star 1 can be classified WN3b, but this value is still very close to the empirically determined limit of 30 Å for broad-lined stars (Smith et al. 1996). If star 1 is really a broad-line star (which are believed to be the true H-free WN stars; Smith & Maeder 1998), then the numerous absorption lines in its spectrum might be caused by an unresolved companion massive star. An indirect support to the binary status of star 1 comes from its position on the plot of EW(5411) versus FWHM(4686) for WN stars in the LMC (see Figure 14 of Smith et al. 1996), where it lies in a region occupied by composite stars. Detailed comparison of the two spectra of star 1 collected on 2011 February 9 and 2011 March 5, however, does not show any evidence of significant change in the radial velocity. However, if the period is long and/or a multiple of our poor time sampling and/or if the eccentricity is high, many more spectra are needed in order to really state if the star is a binary or not. Alternatively, the absorption lines mimicking an O-type spectrum could be intrinsic to star 1 itself (e.g. Foellmi, Moffat & Guerrero 2003).

The spectrum of star 2 is dominated by H and He I absorption lines (Gvaramadze et al., in preparation). No He II lines are visible in the spectrum. Using the Hγ-absolute magnitude calibration by Balona & Crampton (1974) and the measured EW(Hγ)=3.80 Å, we estimated the spectral type of star 2 as B0 V.

The lopsided brightness distribution over the shell and the offset of the WR star from the geometric centre of the shell (see Figure 1) suggest that the star is a run-away (moving from west to east) and that the stellar wind interacts with dense am-

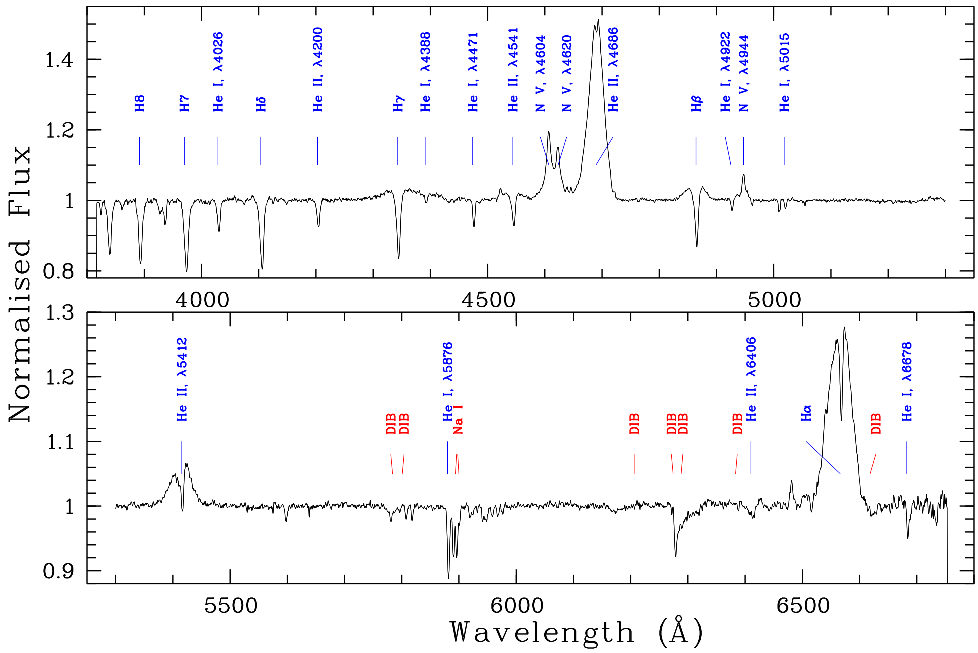

Figure 2. Normalized spectrum of the new WR star (star 1) in the LMC with principal lines and most prominent diffuse interstellar bands (DIBs) indicated.

bient medium (shed during the preceding evolutionary phase) comoving with the star (Lozinskaya 1992; Gvaramadze et al. 2009). Proceeding from this, we searched for known star clusters to the west of the WR star and found that this star was probably ejected from the open cluster NGC 1722 (located at $\simeq$ 94 pc in projection from the star; see Figure 1).

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